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ABSTRACT

The document claims that American Indians are the least represented culturally different population in science-related fields of study. In American Indian community schools, science is still taught using outdated conformity-and-assimilation strategies, which neglect consideration of Native American cultural views. The report describes a study conducted on a 2-week institute for 154 elementary teachers from 23 Indian Nations, that provided an opportunity to obtain new content and methods for teaching science and math. The objectives of this inservice program were to convince teachers that: (1) science was to be taught using an inquiry approach with hands-on manipulatives in a problem solving situation and (2) integration of culture with science was necessary. A pretest-posttest instrument focusing on the objectives was given to the teachers. Results indicate that there were statistically significant increases in participants' understanding of how science and American Indian culture can be integrated and in the valuing of hands-on student centered strategies. The addendum contains three representative activities: Canoe Construction, Mystery Soils, and How Worms Survive. (Contains 10 references.) (PR)

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BIA Workshops: Toward Implementing Self-Determination in Teaching Cultural Science

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Paper presented at the 39th National Convention of the National Science Teachers Association, Houston, Texas, March 30, 1991.

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INTRODUCTION

Since the early immigration of Europeans to North America, culture and ethnicity have long been prominent in shaping a nation's political and social system. Although that system has not always served everyone equally, it has elevated the importance of culture and ethnicity in the larger American society. Throughout the 19th century differing cultural and ethnic views produced ongoing conflict and distrust among many of the new and resident populations. However, those differences were politically narrowed after the turn of the century when preoccupied policy makers allowed assimilationists to enact their new social conformity doctrine (Cubberley, 1909). Goals of the doctrine were to rid cultural and ethnic groups of their traits by forcing Anglo-conformity behavior through social assimilation (Banks, 1981).

In the decades to follow, philosophers and writers presented a case for less conformity and sought greater expression of the social uniqueness of culture and ethnicity. They argued that a cultural pluralistic society would enrich the nation and all would benefit from its many diverse people and their contributions. Yet, it wasn't until the cultural revitalization movements of the last two decades that cultural pluralism was truly considered a viable alternative to cultural and ethnic conformity. Now, cultural pluralism has been translated into what the public and educators alike call, multiculturalism. Like the philosophers from the turn of the century, the purpose of multiculturalism is to create in the person an ability to look at the world through her or his own eyes, and then, make decisions that will enhance personal achievement and self-identity (Baldwin, 1988). Even though its composition and meaning may still be argued globally, it appears this view of culture and ethnicity has developed an acceptance in the institutions of the American society.

Typical of the past century's changing national views of culture and ethnicity were educational policies and programs serving various minority populations. For American Indians, educational policy vacillated between assimilation and self-determination much as did the larger population. While the Immigration Acts were being successfully argued during the 1920s, the Meriam Report (1928) was arguing for massive reform in the administration of American Indian education. Yet, it wasn't until 1969 that Congress learned the Meriam Report recommendations had never been put into operation (Senate Report on Indian Education, 1969). Ironically, however, the same goals proposed by the Meriam Report, *build a school curriculum that reflects the local culture and educational values*, have now become the foundation to the new multiculturalism some 60 years later.

Culture and Ethnicity in the Science Curriculum. Within the changing educational perspectives on culture and ethnicity have also come changes in human acquired knowledge during the past century. For example, science has made unprecedented breakthroughs in its interpretation and understanding of the natural world. Accompanying those discoveries have also been pedagogical changes in how science is to be taught in the schools. Prior to the Sputnik revolution, science was taught more as a body of facts that needed to be committed to memory and understood. Even though remnants of pre-Sputnik science teaching still exist, emphasis now is placed on the importance of presenting science to children as inquiry by using manipulatives with direct experience in problem solving. Not only does this instructional philosophy create greater interest among children, but it also provides them an intellectual scheme for understanding the underlying philosophy and nature of science.

While changes have been occurring in science and science teaching, there are few reports that actually demonstrate the integration of science and culture into local culture and curricula. For example, science is still taught in most American Indian community schools using the conformity and assimilation strategies from the turn of the century. Yet, American Indian cultures do not accept the separation of science from other aspects of their life as do most Anglo-Americans. In fact, there is no word in any traditional American Indian language that can be translated to mean science as it might be defined by Western culture (Cajete, 1986). Yet, expressions of science thinking are abundant throughout traditional American Indian agriculture, astronomy, ecology, and medical practices. In addition, processes of science which include rational observation of natural events, classification, and problem solving are woven into all aspects of American Indian culture (Cajete, 1986). Therefore, if the goals of multiculturalism are to be achieved in a pluralistic society, heighten racial consciousness and concern must be translated into viable programs that meet those goals. One such program was the Bureau of Indian Affairs' Math and Science Institute, sponsored by the Office of Indian Education Programs, Sinte Gleska College, Rosebud, South Dakota; and Haskell Indian Junior College, Lawrence, Kansas.

INSTITUTE AND STUDY DESCRIPTION

Institute Description. During 1990, two 2-week institutes were conducted to provide 154 elementary teachers from 23 American Indian nations an opportunity to obtain new content and methods for teaching science and mathematics. Yet going beyond traditional institute activity, this project included a component designed to study inservicing factors related to teachers in multicultural settings.

Normally, inservicing activities seek to provide curricular and method updates as previously described, but here, the institute objectives were designed to:

1) Convince elementary teachers that science was to be taught to elementary children using an inquiry approach with hands-on manipulatives in a problem solving setting.

2) Persuade elementary teachers that integration of science and culture was not only possible for good science, but that it was also necessary.

This task was accomplished through an intensive hands-on science portion of the institute that used a number of basic persuasion strategies suggested by Ross (1985). Foremost among these was to persuade the participants to recognize their current teaching behavior as it related to hands-on science and the integration of science and culture. Then, alternatives to the former behaviors were provided through intensive institute activity. These alternatives contained sufficient belief material in their content to influence change in individual attitudes, behaviors, beliefs, and emotions. Following the institute presentations and activities, each participant had to personally internalize and voluntarily accept the new proposed patterns of behavior if they were to change. Substantive changes were based upon each participant:

1) Being able to discuss their current beliefs related to the desired change.

2) Recognizing that both their thoughts and activity products would be accepted as valid contributions of their work and thinking.

3) Doing science activities the same way they would be doing them with their students.

4) Recognizing their freedom to explore other alternatives to the assigned activity.

5) Experiencing science activities that integrate science and cultural concepts. (Representative activities in Addendum)

6) Recognizing the positive attitude and classroom climate in which they were working.

Study Description. At the beginning and end of the intensive hands-on science portion of the two Math and Science Institutes, participants were asked to respond to the assessment inventory, "Toward a Philosophy for Teaching Science to American Indian Children." The instrument consisted

primarily of different instructional strategies teachers may use to teach elementary school science. Strategies like:

> *Presents science information to students using a lecture-discussion method.*
>
> *Science process skills are an integral and prominent part of the teaching and learning process.*

However, embedded in the instrument's 30 items were seven strategies that specifically integrated science and the American Indian culture. Such included representatives like:

> *Community elder resource people are an integral part of the science program where they talk about how ancestors inquired and solved problems for everyday living.*
>
> *Medicine Men are appropriately used to reinforce the integration of health, nutrition, and spirituality.*

Items from the latter group were placed in the instrument to determine the amount of current curriculum integration, and also, to seek participant's view toward integrating science and culture in the future.

The assessment procedure required cooperatively grouped consensus on determining the value of each science teaching strategy as it related to participant's dispersal of personal and professional resources, e.g., time, energy, money. In essence, how much value did they place on using a particular strategy in their teaching. The assessment task was accomplished through placement of "value dots" behind each item. Value dots were simply small, red-punched construction paper pieces that could easily be added or subtracted from items as assessment views changed during the activity. All 60 dots were to be used among the 30 assessment items with at least one item receiving a five-dot value. Pre-assessment values centered around participant's current curriculum integration activity, while post-assessment emphasized what they thought should and could be accomplished based upon institute activity. Once the task was completed, group generated data were placed on the chalkboard so all could assess the current status of science teaching among attending participants.

Pre-assessment and post-assessment data generated from the two institutes were statistically analyzed using descriptive statistics (central tendency, variability) and one-way analysis of variance. Overall, individual, and grouped instrument items were analyzed in the study. Grouped items selected for analysis fell into three primary areas: (1) integration of science and cultural strategies, (2) content/teacher-centered

strategies, and (3) hands-on/student-centered strategies. Results are presented in the following report sections.

RESULTS

Analysis of data from the study indicate participants made important shifts in a number of desired areas related to change dynamics for teaching science to American Indian children. Such shifts occurred with items pertaining to integrating science and cultural strategies, content/teacher-centered strategies, and hands-on/student-centered strategies. More specifically, five of the seven strategy items pertaining to the integration of the American Indian culture and science showed statistically significant pre-assessment/post-assessment gains (TABLE I). Such gains occurred in:

> *Community elder resource people are an integral part of the science program where they talk about how ancestors inquired and solved problems for everyday living.*
>
> *Medicine Men are appropriately used to reinforce the integration of health, nutrition, and spirituality.*
>
> *Field trips to local areas are used to study where resources have been harvested for meeting and solving daily needs, e.g., sage, soap weed, skins.*
>
> *Literature of science-related events in the culture (e.g., star stories) is used for its scientific value.*
>
> *Activities to demonstrate science concepts are rewritten to make use of culturally relevant materials and practices.*

When mean values for culturally related items were grouped together, there was a shift from a 1.73 mean value points upon institute entrance to 2.78 at exit (TABLE III). Such significant gains can be contrasted with change ratios for all assessment items grouped together (2.05 to 2.45), and all noncultural items (2.15 to 2.35). These results suggest institute activity contributed to persuade participants to change their understanding of how science and the American Indian culture could be integrated through hands-on activities.

Equally important changes occurred with shifts in items related to content/teacher-centered strategies vs. hands-on/student-centered strategies (TABLE II and III). While content/teacher-centered strategy items like:

> *Present science information to students using a lecture-discussion method.*

Conduct demonstrations in front of class so students learn a scientific approach to investigating the natural world around them.

Students memorize definitions of science words.

made significant declines in value through institute activity (1.67 to .81); hands-on/student-centered strategy items like:

Activities are taught that allow students to explore science materials before they invent concepts to explain them.

Written materials include liberal quantities of hands-on investigations and activities that children can actually do.

Science process skills are an integral and prominent part of the teaching and learning process.

Increased permissiveness within exploration and inquiry activities is used to increase the emphasis on creativity rather than on achievement.

made significant offsetting gains in value (2.48 to 3.25) (TABLE III). These mean value changes that showed statistically significant increases in integrating science and cultural strategies, decreases in content/teacher-centered strategies, and offsetting increases in hands-on/student-centered strategies, substantiate relative success of overall institute objectives and activities.

DISCUSSION AND IMPLICATIONS

The objective of the intensive hands-on science portion of the institute was to persuade participants to teach science using a direct-experience or hands-on approach that incorporated all aspects of the American Indian culture. Analysis results from three areas of the supporting study indicate that significant progress had been made toward reaching those goals. First, there was an increase in score values for understanding the need for hands-on science. Accompanying those scores were parallel gains in the incorporation of culture into the hands-on strategies, as well as, declines in the need for use of content-oriented teaching strategies. Together, those results provided greater understand of the overall inservicing task needed to improve science teaching for American Indian children.

In 1977, an American Association for Advancement of Science report stated that the primary barrier to American Indian participation in science was its lack of relevance to Indian

lives and their survival as a culture. This institute and accompanying study took steps to remedy those barriers through positive integration of culture into the inservicing process. However, when a review of literature in this area was conducted, few examples concerned themselves with the nature and culture of the teacher involved in the inservice process. This may not appear to be significant for European-Americans, but those unspoken messages for American Indians can only propagates the misnomer that the user of science is a servant to its preordained doctrine. That mind set parallels that of the assimilationists' Anglo-conformity doctrine, and in either instance, integration of science and culture do not benefit.

Today, American Indians are the least represented culturally different population in science-related fields of study. This has been a concern of those seeking to see greater participation; however, examples from the literature again only substantiate the lack of understanding for the level and degree of integration that normally exists between science and the traditional American Indian cultures (Haukoos & Beauvais, 1985; Robbins, 1983). If the perceived lack of relevance is to be overcome, responsible educators must continue to find ways of integrating culture and hands-on science within a multiculturalism philosophy of education. As Hodgkinson (1985) pointed out, one in every three Americans will be a minority by the year 2000. While this large nonwhite population will add a high level of energy and creativity to the nation, its failure could lead to diminished lives for all. Similarly, if American Indian values and cultural views of science are not woven into the more global fabric of the philosophy of science, all aspects of science and technology will be diminished in years to come.

Results of this study suggest that when model activities representing integrated science and culture are presented in an appropriate classroom climate, teachers can be persuaded to accept new patterns of instructional behavior. Not only was it important for teachers in this setting to learn the importance of hands-on/student-centered science and its integration with culture, but it was also important for them to experience its delivery in a classroom climate where environmental variables were appropriately managed. Under such conditions, teachers can develop a multicultural view of education that will contribute to the growth and development of all people that share the Earth together.

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TABLE I

Changes in Assessed Values for All Items Denoting Curriculum Integration of Science and Culture

4. Students meet or read about successful Indian, Hispanic, or Black scientist role models.

	SS	DF	MS	F	P
Between	.82	1	.82		
Within	1096.22	65	16.87		
Total	1097.05	66		.05	1.000

Pre-assessment mean	2.22
Post-assessment mean	2.00

8. Community elder resource people are an integral part of the science program where they talk about how ancestors inquired and solved problems for everyday living.

	SS	DF	MS	F	P
Between	46.47	1	46.47		
Within	96.80	61	1.59		
Total	143.27	62		29.28	<.001

Pre-assessment mean	1.48
Post-assessment mean	3.21

13. Study science-related problems which influence the future of Indians, e.g., nutrition, AIDS, land use.

	SS	DF	MS	F	P
Between	1E-03	1	1E-03		
Within	159.53	74	2.16		
Total	159.53	75		1E-03	1.000

Pre-assessment mean	2.93
Post-assessment mean	2.92

17. Medicine Men are appropriately used to reinforce the integration of health, nutrition, and spirituality.

	SS	DF	MS	F	P
Between	9.19	1	9.19		
Within	86.96	55	1.58		
Total	96.14	56		5.81	.018

Pre-assessment mean	.72
Post-assessment mean	1.52

19. Field trips to local areas are used to study where resources have been harvested for meeting and solving daily needs, e.g., sage, soap weed, skins.

	SS	DF	MS	F	P
Between	53.22	1	53.22		
Within	86.44	69	1.25		
Total	139.66	70		42.48	<.001

Pre-assessment mean	1.66
Post-assessment mean	3.39

23. Literature of science-related events in the culture (e.g., star stories) is used for its scientific value.

	SS	DF	MS	F	P
Between	27.12	1	27.12		
Within	177.52	67	2.65		
Total	204.64	68		10.24	<.01

Pre-assessment mean	1.81
Post-assessment mean	3.06

25. Activities to demonstrate science concepts are rewritten to make use of culturally relevant materials and practices.

	SS	DF	MS	F	P
Between	69.39	1	69.39		
Within	132.76	63	2.11		
Total	202.15	64		32.93	<.001

Pre-assessment mean	1.31
Post-assessment mean	3.39

TABLE II

Changes in Assessed Values for Items Denoting
Content/Teacher-Centered Strategies vs.
Hands-on/Student-Centered Strategies

Content/Teacher-Centered Strategies:

1. Present science information to students using a lecture-discussion method.

	SS	DF	MS	F	P
Between	49.99	1	49.99		
Within	103.86	62	103.86		
Total	153.85	63		29.84	<.001

Pre-assessment mean	2.18
Post-assessment mean	.39

2. Conduct demonstrations in front of class so students learn a scientific approach to investigating the natural world around them.

	SS	DF	MS	F	P
Between	45.01	1	45.01		
Within	135.05	66	2.04		
Total	180.06	67		21.99	<.001

Pre-assessment mean	3.11
Post-assessment mean	1.47

3. Present science theories to students and then conduct investigations to prove those theories.

	SS	DF	MS	F	P
Between	.11	1	.10		
Within	127.61	61	2.09		
Total	127.71	61		.05	1.000

Pre-assessment mean	1.15
Post-assessment mean	1.23

5. Students memorize definitions of science words.

	SS	DF	MS	F	P
Between	14.58	1	14.58		
Within	80.41	57	1.41		
Total	94.98	58		10.34	<.01

Pre-assessment mean	1.43
Post-assessment mean	.42

TABLE II
Page 2

9. Students receive detailed and specific instructions for each step when they conduct investigations, analyze data, and seek correct answers and conclusions.

	SS	DF	MS	F	P
Between	2.40	1	2.40		
Within	89.81	60	1.50		
Total	92.21	61		1.60	.208

Pre-assessment mean	1.29
Pre-assessment mean	.89

18. Students memorize classification schemes and definitions as a scientific approach to nature study.

	SS	DF	MS	F	P
Between	2.44	1	2.44		
Within	74.12	54	1.37		
Total	76.55	55		1.78	.185

Pre-assessment mean	.86
Post-assessment mean	.44

Hands-on/Student-Centered Strategies:

10. Activities are taught that allow students to explore science materials before they invent concepts to explain them.

	SS	DF	MS	F	P
Between	17.99	1	17.99		
Within	176.00	70	2.51		
Total	193.99	71		7.15	<.01

Pre-assessment mean	2.00
Post-assessment mean	3.00

12. Students have an opportunity to do group explorations and draw group conclusions.

	SS	DF	MS	F	P
Between	4.00	1	4.00		
Within	132.74	71	1.87		
Total	136.740	72		2.14	.144

Pre-assessment mean	3.13
Post-assessment mean	3.60

TABLE II
Page 3

14. Use written materials that encourage children to explore, discover, and find answers for themselves rather than telling them how things should turn out.

	SS	DF	MS	F	P
Between	1.02	1	1.12		
Within	198.44	64	3.10		
Total	199.46	65		.33	1.000

Pre-assessment mean	1.97
Post-assessment mean	2.22

16. Written materials include liberal quantities of hands-on investigations and activities that children can actually do.

	SS	DF	MS	F	P
Between	10.48	1	10.48		
Within	204.68	74	2.77		
Total	215.16	75		3.79	.053

Pre-assessment mean	2.52
Post-assessment mean	3.26

20. During students' investigations, teacher functions as a guide by assisting individuals, asking questions, suggesting alternative procedures or thinking.

	SS	DF	MS	F	P
Between	4E-03	1	4E-03		
Within	166.48	73	2.28		
Total	166.48	74		2E-03	1.000

Pre-assessment mean	3.57
Post-assessment mean	3.55

21. Science process skills are an integral and prominent part of the teaching and learning process.

	SS	DF	MS	F	P
Between	42.88	1	42.88		
Within	140.65	66	2.13		
Total	183.53	67		20.12	<.001

Pre-assessment mean	1.85
Post-assessment mean	3.44

TABLE II
Page 4

22. Students are encouraged to formulate new questions, restate problems in their own words, and create ideas.

	SS	DF	MS	F	P
Between	9.57	1	9.57		
Within	594.20	67	8.87		
Total	603.77	68		1.08	.303

Pre-assessment mean	2.27
Post-assessment mean	3.62

26. Increased permissiveness within exploration and inquiry activities is used to increase the emphasis on creativity rather than on achievement.

	SS	DF	MS	F	P
Between	17.00	1	17.00		
Within	143.12	66	2.17		
Total	160.12	67		7.84	<.01

Pre-assessment mean	2.21
Post-assessment mean	3.21

28. Provide activities that encourage a science attitude through careful thinking, open-mindedness, and neutral observation.

	SS	DF	MS	F	P
Between	5.39	1	5.39		
Within	136.11	70	1.94		
Total	141.50	71		2.77	.097

Pre-assessment mean	2.79
Post-assessment mean	3.34

TABLE III

Changes in Pre-Assessment and Post-Assessment Grouped Item Value Points

Strategy Item Groups	Pre-Assessment Mean	Post-Assessment Mean
Culturally Related	1.73	2.78
Nonculturally Related	2.15	2.35
Content/Teacher-Centered	1.67	.81
Hands-on/Student-Centered	2.48	3.25
All Assessment Instrument Items	2.05	2.45

Addendum

Representative Activities

Canoe Construction
Mystery Soils
How Worms Survive

Sample Activity
Adapted by
G. Haukoos

Canoe Construction

Purpose:	To provide students an opportunity to explore the concept of buoyancy through firsthand experiences with various canoe construction materials. Through these experiences students will solve problems, make inferences and predictions, and develop and test hypotheses.

Materials:

Modeling clay (5-7 cm. ball)
Waxed paper (15 cm. square)
Aluminum foil (15 cm. squares of heavy-duty)
Pails of warm water
Plastic boxes
Sinkers (e.g., marbles, washers, pennies)
Miscellaneous objects as cargo
Dowels or other rollers
Masking tape, Rulers, Scissors, Stapler
Paper towels, Sponges, Mop

Procedures:

1. Tell students a story about early ancestors completing their fall hunt far from the community lodges back in the lake and river country. They had been successful and had large piles of skins, bones, antlers, and meat that needed to be transported home for the winter. However, they needed canoes.
2. With the materials provided, design and test canoes and their capacity to hold the needed cargo. Keep a record through written notes and/or pictures.
3. Provide each pair of students the waxed paper, aluminum foil, and ball of clay. Also provide a plastic box and warm water to simulate a testing lake. Make other materials available as needed--such as tape, scissors, stapler, etc.
4. Provide sample cargo to test capacities of their various canoes. (small corks and ceramic chips)
5. Encourage students to test the waxed paper first with light weight cargo (corks), then move to foil, and ultimately to clay.
6. Encourage students to test different shapes of boats, bottoms, heights of sides, thickness of clay, etc.
7. Teacher is always circulating and asking inquiry questions.

Discussion:

8. Once boats and materials have been tested, list on the chalkboard "ways to make a canoe hold more--." Discuss.

Conclusion:

9. Using uniform heavy cargo and time, predict and then have a contest to see which boats hold the most sinkers. (ceramic chips)
10. Conclude with class developing one hypothesis to explain all events of the day.

Sample Activity
Adapted by
G. Haukoos

Mystery Soils

Purpose:	To provide students opportunity to determine attributes of different substances through careful and accurate testing and record keeping.

Materials:

Waxed paper	Droppers
Plastic spoons	Toothpicks
Hand lenses	Food coloring
Heat source (Sterno)	Clothespins
Mystery soils (6)	Test solutions (4)

Procedures:

1. Tell students a story about living in the southwest and for some reason, the clay used in building homes has become poor in quality. You and other members of your community searched and found deposits of unknown soils that may be useful in improving current clay. Now, they need to be tested.
2. With the materials provided, design and test each of the six mystery soils for the way it may improve current clay and future homes. Particularly look for its ability to be beneficial under different conditions. Keep careful record of what each test shows and how that would improve the current clay.
3. Give each student a piece of waxed paper on which to make the tests and a piece of desk paper for keeping records. Then provide groups of students droppers, toothpicks, hand lenses, four testing solutions, and six mystery soils. Only provide heat and clothespins when above have been completed (demonstrate this process).
4. Work time with teacher inquiry questions as s/he moves around the room.
   - How are the soils alike?
   - How are they different?
   - Do they feel the same?
   - Does any powder have an odor?
   - Are they the same shade of color?
   - Can you list three properties of each soil?
5. At the end of your data sheet, provide an overall ranking of the mystery soils for their ability to improve the clay now being used. Give a short explanation for each.

Discussion and Implications:

6. Review class data on the chalkboard with the students. Have them make explanations and implications for improving community homes.

Suggested Activity
Adapted by
G. Haukoos

How Worms Survive!

Purpose:	To develop the concepts of protective coloration and natural selection in populations of animals. In addition, students will be actively participating in collecting, recording, and interpreting data.

Materials:
Colored pipe cleaners (4-5 colors)
Plastic Ziploc bags (large, number one-third each with #1, #2, #3)
Graph paper (or butcher paper and markers)

Procedures:

1. Tell students a story about Joseph, a young boy in your community who took an afternoon walk to visit his friend Guy down the road. On the way he noticed a number of brightly colored birds calling and chasing each other so he decided to throw stones at them. Might there have been other birds in the bushes he didn't notice? What brought his attention to the stoned birds? (color, noise, size, etc.)
2. About 100 years ago in another area of the country the forests were filled with pepper colored moths. Today none of the pepper moths can be found, but in their place are dark colored relatives. During this 100 years the nearby city has grown and produces a lot of pollution over the forest. What may have caused the change from pepper colored to dark colored moths?
3. Today we're going to make a similar study to get answers to our two stories.
4. OUTSIDE: Pre-scatter worms (cut pipe cleaners) in one particular area, e.g., grass, play lot.
5. Count off students by the number of groups desired for the activity. Assign each a bird name and give numbered bags.
6. Take everyone to the worm field and give all a short time to flyby the field collecting as many worms as possible. Place worms in bag #1.
7. Repeat flybys two more times placing worms in appropriately numbered bags.

Discussion:

8. Return to the classroom and discuss the colors observed in the three bags. How do they differ? What may have caused this?
9. Provide each person graph paper to design a graph of the events.

Conclusion:

10. Conclude with such questions as: What do you observe about the <u>number</u> of worms picked up during the three flybys?...the <u>color</u> changes during the flybys?
11. Finally, why did Joseph only throw stones at certain birds? Where did the pepper colored moths go but the dark colored moths live today?